ANATOMICAL OBSERVATIONS ON A COLLECTION OF ORANG SKULLS FROM WESTERN BORNEO; WITH A BIBLIOGRAPHY

BY

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Assistant Curator, Division of Physical Anthropology, U. S. National Museum

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INTRODUCTION.

In January, 1906, the United States National Museum received from Dr. W. L. Abbott 26 orang skulls, 24 of which were collected along the Sakaiam River, in Landak, western Borneo, the remaining two being from the Landak River, in the same region. The Sakaiam is a large tributary of the lower Kapuas; it flows from the southern slopes of the elevations that form the southwestern boundary of Sarawak, and joins the Kapuas at Sangou, very near the equator and at about 110° 40′ east longitude.

Doctor Abbott's collection of orang skulls is probably the largest yet made in that region. Selenka's great collection in Munich includes 22 "Landak" orang skulls, but the exact location is not given; the rest of Selenka's abundant material was derived entirely from the territory of the Ketungan stream, lying considerably to the northeastward of the Sakaiam.

Only four of Doctor Abbott's specimens are fresh, the apes having been killed by his hunters; the expedition was made in the dry season, after the orangs had abandoned the lowlands along the rivers, where the wild fruits had become exhausted. The additional crania were obtained from a Dyak house, where, according to the custom of the natives, they had been hung up as trophies, the animals having been killed, cooked, and eaten. Most of these older specimens were only slightly damaged and remain fit for study. No one of the skulls is altered through any pathological condition.

Anatomical description of the above-named specimens seems desirable for several reasons. This is a large collection from a limited locality, representing, very probably, one species or "race" of the apes. The results of the study should contribute to the anatomical knowledge of orang crania in general, augment the value of the data accumulated

by Dumortier, Delisle, Owen, Selenka, Walkhoff, etc., for anthropological comparisons, and also form a basis for the collation of orang skulls from other localities.

The question as to which species of orangs the crania belong must for the present remain unanswered, on account of the existing uncertainties as to the species-distinguishing marks on the skull. Presumably, the animals are nearest related to the "Landak race" of Selenka.

The technical terms in the description are those that are in general use in craniometry and anatomy.[a]

OBSERVATIONS.

Age.—The first problem in the examination of Doctor Abbott's series, was how to determine the fully adult skulls from those of younger animals. It was found that:

(1) No reliance can be placed on the condition of the sutures of the cranial vault as indicative of age. The lambdoid and then the sagittal, both of which in man remain open long into adult life, in the orangs begin to synostose even before the completion of the second dentition; and the coronal, in its superior half, soon follows in occlusion upon the sagittal suture. The inferior portion of the coronal and the temporo-parietal articulation are more stable and become fully obliterated only about the time when other signs indicate that the growth of the animal has been completed. Thus it is only the state of these last two sutures that may aid in determining the adult period.

(2) The facial sutures remain patent longer than most of those of the cranial vault. The first to synostose is the intermaxillary articulation, the next those of the malar bone, and last of all the nasal, and pieces of one or two orbital sutures. The closure of the intermaxillary articulation precedes the attainment of full growth; that of the malar sutures is about cotemporary; while parts of the nasal articulations and an orbital segment or two may persist open for some time after the adult stage of life has been attained.

(3) Obliteration of the basilar suture seems to correspond very closely with the reaching of full growth, and, as in man, it will be found of all the signs the most reliable in separating adult from younger orang crania.

(4) The completion of the second dentition in orangs is not a criterion that the adult life has been reached, for it takes place before the full growth of the animal is achieved. The wear and pitting of the teeth begin also during adolescence, soon after the eruption of the third molars.

(5) In males the fusion of the temporal ridges and the formation therefrom of a sagittal crest appear to correspond closely with reach-

[a] See Quain's or Cunningham's Anatomy, or Topinard's Anthropology.

ing the adult stage. In females this sign is much less accentuated and is not to be relied upon.

By the above distinguishing marks Doctor Abbott's collection is separable into one young, twelve adolescents, and thirteen adults.

Among the adolescents the second dentition (32 teeth) is fully completed in ten; while in two (Cat. Nos. 142183, and 142200), the third molars are still wholly in their sockets. Of the adult crania several show signs of aging, but none of advanced senility.

Sex.—The principal signs which characterize the adult male orang skulls are a relatively greater size of the crania, great canine teeth, and a pronounced sagittal crest; while the jaws, particularly the lower, the malars, zygomatic processes, supraorbital ridges, lambdoid crest, and the face, vault, and base as a whole, are larger and heavier than in the females. Judging by these characteristics, the collection contains thirteen male and eleven female skulls; in one specimen (Cat. No. 142184), after repeated examinations, the sex remains doubtful.

The angle of the lower jaw,[a] which in man is a good sexual character, can not be much relied upon in differentiating orang skulls, as will be seen from the following table:

Mandibular angle in orangs.

Cat. No.	Sex.	Stage of life.	Angle.	Cat. No.	Sex.	Stage of life.	Angle.
142183	Male	Adolescent	107°	142201	Female	Adolescent	103°
142195	do	do	117	142202	do	do	113
142188	do	do	110	142170	do	Near adult	110
142200	do	do	106	142169	do	Adult	116
142181	do	Near adult	112	142187	do	do	111
142196	do	Just about adult.	108	142182	do	do	106
				142190	do	do	108
142198	do	do	105	142191	do	Adult (aging).	116
142194	do	Adult.	111				
142192	do	do	108				
142199	do	do	1 2				
142189	do	Adult (aging).	101				
Average			109	Average			111
Range			101–117	Range			106–116

The average difference between the two sexes is seen to amount to scarcely 2 degrees, and the ranges of individual variation overlap so greatly as to be quite similar.

In No. 142184, which by the size of the canines approaches the male but by other characteristics is nearer the female skulls, the angle is 114°. In the young specimen (Cat. No. 142171), a female having all the teeth of the first dentition but only the first molars and the left lower lateral incisor of the second dentition, the angle measures 112°.

[a] Measured on Broca's mandibular goniometer.

CRANIAL CAPACITY.

The cranial cavity appears to have reached the limit of its expansion in nearly all the specimens, so that it is not necessary to exclude more than one (Cat. No. 142171) from comparison.

The method used in determining the capacity was that described by the writer on a former occasion,[a] and the results correspond closely with the absolute volume of the cranial cavity. To insure accuracy four determinations were made on each skull. The results were as follows:

Cranial capacity.

Cat. No.	Sex.	Age.	Cubic centimeters.	Cat. No.	Sex.	Age.	Cubic centimeters
142183	Male	Adolescent	440	142201	Female	Adolescent	400
142195	do	do	510	142202	do	do	360
142188	do	do	465	142193	do	Near adult	325
142197	do	Near adult	435	142170	do	do	340
142181	do	do	425	142169	do	Adult	345
142196	do	Just about adult.	465	142185	do	do	350
				142187	do	do	335
142198	do	do	450	142182	do	do	340
142194	do	Adult	405	142190	do	do	320
142192	do	do	480	142186	do	Adult (aging).	380
142199	do	do	430	142191	do	do	390
142189	do	Adult (aging).	415				
Average			450	Average			353
Range			405–540	Range			320–400

In Cat. No. 142184, the skull of the adolescent orang, the sex of which is doubtful, the capacity is 450 cc.

The writer searched the literature for other determinations of this measurement and found a number of records, which it will be of interest to introduce here for comparison. The capacities were obtained by different but related methods, and are capable of collation.

Former measurements of cranial capacity in full-grown orangs, with known sex:

Lucae,[b] two adult males; in one "the cranial cavity takes 12 ounces," the other "not quite 12 ounces," of millet seed.

Owen, R.,[c] one adult male, 26 cubic inches; one adult female, 24 cubic inches.

Lucae,[c] 1 orang, probably adult, 450 cc.; 1 orang, adult, 420 cc.; 1 orang, adult, 370 cc.; 1 orang, adult, 360 cc.; 1 orang, adult, 335 cc.

Duvernoy,[c] one orang, adult, 475 cc.; one orang, adult, 460 cc.

Krauss,[c] one orang, adult, 480 cc.

[a] A Modification in Measuring Cranial Capacity, Science, n. s., XVII, pp. 1011–1014, June 26, 1903.

[b] J. Ch. G. Lucae, Der Pongo—und der Orang—Schädel in Bezug auf Species und Alter, Auftr. d. Senckenberg. naturf. Gesellsch., F. Tiedemann gewidmet, 10 Marz, 1854, pp. 154–167.

[c] Trans. Zool. Soc., London, IV, 1862, p. 86.

Welcker,[a] one orang, adult, 460 cc.; one orang, nearly adult, 450 cc.; one orang, adult, 390 cc.

Bischoff,[b] one orang, adult, 575 cc.; one orang, adult, 370 cc.; 1 orang, adult, 325 cc.

Topinard,[c] three orangs, males, adult, 439 cc. (433–478 cc.); one orang, female, adult, 418 cc.

Vogt,[d] eight orangs, males, 448 cc. (390–500 cc.); seven orangs, females, 378 cc. (335–425 cc.).

Delisle,[e] first, 385 cc.; second, 470 cc.; third, 475 cc.; fourth, 430 cc.; fifth, 410 cc.; sixth, 395 cc.; seventh, 445 cc.; eighth, 390 cc.; ninth, 340 cc.; tenth, 355 cc.[f]

Selenka's measurements are as follows:

Selenka's measurements of the cranial capacity.[g]

Race.	Total number of skulls.	Males—adults.		Females—adults.	
		Average cubic centimeters.	Range.	Average cubic centimeters.	Range.
Batangu	14	430	380–460	360	330–380
Dadap	38	500	410–534	430	400–490
Genepai	22	390	360–430	370	350–410
Landak	22	430	410–440	370	350–400
Rantai	2	.....	.....	335	321–349
Skalau	89	440	370–500	370	300–450
Tunak		.....	.....	(?)	400–470
Wallaces	6	.....	.....	(?)	310–360
Sumatranus deliensis	5	(?)	385–445	(1)	340

[a] In C. Vogt, Ueber die Microcephalen oder Affen-menschen, Arch. f. Anthropol., II, 1867, p. 185.

[b] Th. L. Bischoff, Ueber die Verschiedenheit in der Schädelbildung des Gorilla, Schimpanse und Orang-Utan, München, 1867, p. 29. Measured with millet seed; gives the largest as female, but from description it is clear it was that of a male.

[c] P. Topinard, Anthropology, London, 1878, p. 48. Capacity determined by "small shot." (Probably Broca's method.)

[d] Idem, p. 49. Used millet seed principally.

[e] F. Delisle, Notes sur l'ostéometrie et la craniologie des orang-outans, Nouv. Arch. du Mus. d'hist. nat., 3d ser., VII, Paris, 1895, p. 106. Used Broca's method, which gives slightly exaggerated results.

[f] Only one of these ten appeared to be that of a female.

[g] E. Selenka.—Studien ueber Entwickelungsgeschichte der Tiere, 6, Menschenaffen, Wiesbaden, 1898, p. 8. Measured by Ranke's method, with millet seed. Gives also the following data as to the young. For other results in young, see C. Vogt, Ueber die Microcephalen oder affen Menschen, Arch. f. anthropol., II, 1867, p. 185.

Selenka: Young (Skalau), males.

	Cubic centimeters.
1. No teeth as yet	292
2. All teeth of first dentition except canines	297
3. All teeth of first dentition	313
4–7. All first molars of second dentition visible, deep	363–368
8. All first molars of second dentition erupted	400
9–13. All first molars of second dentition erupted, second molars visible, deep	378–400

On combining these data on cranial capacity in full-grown orangs it is found that the measurement ranges in the males from 355 (Delisle) to 540 (Abbott) and even 575 (Bischoff), and in the females from 300 (Selenka) to 490 (Selenka), which is a great variation. The greatest and smallest capacities in the Abbott series are not attended with any other structural peculiarities which would point to animals belonging to distinct species, and must be ascribed solely to individual diversity.

LINEAR DIMENSIONS AND FORM OF THE SKULL.

Measurements of the cranial vault in orangs and particularly in the males offer difficulties which are not encountered in man. The region above the nasal bone, corresponding in part to the human glabella, varies much even in the same sex and is not suitable for the anterior starting point of the long diameter of the vault. The point chosen instead was the intersection of the median line with a horizontal line obtained by passing the rod of the sliding compass down the frontal bone until it rested on the orbital arches. This point marks very nearly the anterior boundary of the vault, and corresponds closely to Broca's ophryon as well as to the point from which Schwalbe, Selenka, and Kohlbrügge measured. The length was measured from that *ad maximum*, which generally corresponds to some point on the vertical occipital ridge. The breadth was the greatest diameter at the height of the temporo-parietal sutures, the temporal bone below expanding in thickness and rendering all measurements over it impracticable. Selenka[a] measured the breadth in much the same manner. The height taken was the standard one, basion to bregma (or where crest existed to its base over bregma). The following table gives the results of these measurements:

Cranial measurements.

Male orangs.					Female orangs.				
Cat. No.	Length.	Breadth.	Length-breadth index (length = 100).	Height.	Cat. No.	Length.	Breadth.	Length-breadth index (length = 100).	Height.
	Cm.	*Cm.*		*Cm.*		*Cm.*	*Cm.*		*Cm.*
142183	11.8	10.2	86.4	9.3	142201	12.0	9.8	81.7	9.2
142195	13.0	11.2	86.1	[b] 11.5	142202	11.3	9.2	81.4	(?)
142188	12.3	10.2	82.9	11.1	142193	11.2	9.2	82.1	9.1
142200	(?)	10.0	(?)	9.4	112170	11.2	9.2	82.1	9.3
142197	12.1	10.3	85.1	(?)	142169	11.3	9.3	82.3	9.2
142180	(?)	10.0	(?)	(?)	142185	11.5	8.9	77.4	9.4
142181	11.9	9.4	79.0	9.5	142187	11.2	9.1	81.2	8.8
142196	12.1	9.7	80.2	(?)	142182	11.5	9.8	85.2	8.9
142198	12.6	10.0	79.4	10.3	142190	11.2	9.2	82.1	9.0
142191	12.3	9.7	78.9	9.5	142186	11.7	9.6	82.0	8.6
142192	12.7	10.0	78.7	[b] 10.0	112191	11.8	9.5	80.5	8.7
142199	12.1	9.8	81.0	[b] 9.6					
142189	12.4	9.4	75.8	[b] 9.2					
Average	12.5	10.0	80.0	9.9	.....	11.4	9.3	81.7	9.0
Range	11.8	9.4	75.8	9.2	.....	11.2	8.9	77.4	8.6
	13.0	11.2	86.4	11.5	.....	12.0	9.8	85.2	9.4

[b] Approximately.

[a] Studien ueber Entwickelungsgeschichte der Tiere, 1898, pp. 22, 23.

The data show, in conformity with those on capacity, that in orangs the cranial vault grows very little after the eruption of the third permanent molars. The cranial index in half of the males and nearly all the females is moderately brachycephalic, in the other half of the males and one female mesocephalic. The predominance of moderate brachycephaly agrees with former observations. In the males the index appears to decrease somewhat with growth, which is largely due to the increasing thickness of the vertical occipital ridge; in the females such difference is not noticeable. The height shows a reciprocal compensation with the breadth. On the average, the female skull is both absolutely and relatively lower than that of the male. (Height-length index, male 81, female 78; Height-breadth index, male 99, female 96.) The range of variation, except with the cephalic index in the males, can not be regarded as excessive.

MEASUREMENTS OF THE FACE.

The lower jaw attains in the males remarkable proportions, showing at the same time more variation than does that of the females. The height of the symphysis, from the highest point of the alveolar process in the median line perpendicularly downward,[a] measured as follows:

Cat. No.	Male lower jaws.	Vertical height of symphisis.	Cat. No.	Female lower jaws.	Vertical height of symphisis.
		Cm.			*Cm.*
142183		4.4	142201		4.5
142195		5.6	142202		4.5
142188		5.6	142184		4.3
142200		5.3	142170		4.4
142197		6.4	142169		4.9
142180		5.9	142187		5.2
142181		5.2	142182		4.5
142196		6.0	142190		4.4
142198		5.7	142191		4.5
142194		6.9			
142192		5.8			
142199		6.2			
142189		6.5			
Average		5.9	Average		4.6
Range		5.2–6.9	Range		4.3–5.2

Some of these mandibles are really very large; thus, No. 142194 measures, in line with the border of the alveolar process, 16.4 cm. in length with the vertical ramus 10.5 cm. high and 6.15 cm. in minimum breadth; and it weighs, less both canines and three incisors, 344 grams.

The data concerning the angle of the lower jaw were given before. (See under sex.)

Two measurements were taken on the upper portion of the face, namely, (1) the height from the lowest point on the upper alveolar border to the highest point of the naso-frontal suture, and (2) the diameter bizygomatic maximum. Both of these measure-

[a] On Broca's mandibular goniometer.

ments are used extensively in anthropometry and their relation $\left(\frac{\text{facial height, upper,} \times 100}{\text{diam. bizygomatic max.}}\right)$ gives the upper facial index of Kollmann. Doctor Abbott's series of orangs shows in these particulars as follows:

Facial dimensions.

Male orangs.				Female orangs.			
Cat. No.	Height (alveon a-nasion).	Breadth (diam. bizygomatic maxim).	Index.	Cat. No.	Height (alveon-nasion).	Breadth (diam. bizygomatic maxim).	Index.
	Cm.	*Cm.*			*Cm.*	*Cm.*	
142183	7.9	12.7	62.2	142201	8.0	12.4	64.5
142195	10.4	14.5	71.7	142202	8.0	12.4	64.5
142188	10.6	15.3	69.3	142193	9.2	13.0	70.8
142200	10.3	14.7	70.1	142170	9.4	13.2	71.2
142197	11.8	16.5	71.5	142169	10.1	13.4	75.4
142180	11.4	16.3	69.9	142185	8.9	12.8	69.5
142181	11.3	16.1	70.2	142187	9.9	13.2	75.0
142196	11.2	17.3	64.7	142182	8.8	13.5	65.2
142198	12.3	16.7	73.6	142190	9.2	13.3	69.2
142194	12.1	16.9	71.6	142186	9.4	13.1	71 8
142192	12.4	16.9	73.4	142191	8.4	12.4	67.7
142199	12.4	16.5	75.1				
142189	10.9	16.7	65.3				
Average.	(of lower 9) 11.8	(of lower 9) 16.7	(of lower 12) 70.5	Average.	(of lower 9) 9.3	(of lower 9) 13.1	(of lower 9) 70.6
Range...	(9) 10.9–12.4	(9) 16.1–17.3	(12) 64.7–75.1	Range...	(9) 8.4–10.1	(9) 12.4–13.5	(9) 65.2–75.4

[a] Lowest point in the median line of the upper alveolar process.

The males and females are seen to differ greatly in absolute size, but the relative proportions (upper facial indices) are, in average, as well as in range, almost identical. Quite an extensive variation in size and shape exists in both sexes. The male crania show that facial growth in that sex does not cease before the apes become fully adult.

Comparison of the facial with the cephalic index, given in the following table, displays a lack of correspondence; the facial growth is apparently controlled, unlike in man, much more by the development of the teeth and facial muscles than by that of the cranial vault.

Facial compared with cephalic index.

Males.				Females.			
F. I.	C. I.	F. I.	C. I.	F. I.	C. I.	F. I.	C. I.
62.2	86.4	73.6	79.4	64.5	81.7	75.0	81.2
71.7	86.1	71.6	78.9	70.8	82.1	65.2	85.2
69.3	82.9	73.4	78.7	71.2	82.1	69.2	82.1
71.5	85.1	75.1	81.0	75.4	82.3	71.8	82.0
70.2	79.0	65.3	75.8	69.5	77.1	67.7	80.5
64.7	80.2						

Facial prognathism is very largely alveolar. In some of the orang skulls of Doctor Abbott's series (as, for instance, in No. 142189) this is so marked that the face from above downward presents a decided con-

cavity. The maximum of the protrusion is reached with the completion of the second dentition; and contrary to what is observed in man, but in accord with the differences in the size of the teeth, the prognathism is generally greater in the male. The next table gives the gnathic index of the various skulls, obtained by the method of Flower $\left(\frac{\text{basi-alveolar length} \times 100}{\text{basi-nasal length}}\right)$.

Measurements of prognathism.

Male orangs.				Female orangs.			
Cat. No.	Basion-alveon length.	Basion-nasion length.	Gnathic index (Flower.)	Cat. No.	Basion-alveon length.	Basion-nasion length.	Gnathic index.
	Cm.	*Cm.*			*Cm.*	*Cm.*	
142183	13.5	9.2	147	142201	13.3	9.1	146
142188	16.6	10.2	163	142193	13.5	9.0	150
142200	16.3	9.9	165	142170	14.4	9.2	157
142181	17.5	10.4	168	142166	15.0	9.7	155
142196	16.3	10.2	160	142185	14.4	9.4	153
142198	17.8	10.6	168	142187	15.0	9.4	160
142194	17.0	10.0	170	142182	14.0	9.3	151
142192	19.0	10.8	176	142190	13.7	8.9	154
142199	17.2	9.9	174	142186	14.0	9.0	156
142189	17.6	10.6	166	142191	14.4	9.2	157
Average.	(of lower 7) 17.5	(of lower 7) 10.4	(of lower 7) 169	Average..	(of lower 9) 14.3	(of lower 9) 9.2	(of lower 9) 155
Range ..	16.3	9.9	160	Range...	13.5	8.9	150
	19.0	10.8	176		15.0	9.7	160

The most prognathic female, it is seen, just reaches the grade of facial protrusion observed in the least prognathic male. It will also be observed that the males show again a greater variation.

Orbits.—The orbits are, with one single exception, all of greater height than breadth. The rare, if not unique exception in orangs, is the right orbit of No. 142196, the index of which is 98.6, approaching the megaseme orbits of human crania; the right orbit shows in general a slight tendency to an excess over the left in breadth combined with a defect in height. The same phenomena is present in man, where it is accompanied by, and probably stands in some connection with, a perceptibly greater obliquity of the right palpebral fissure. The average orbital index does not differ much in the two sexes, especially after full growth. The two extremes of shape among the females occur in the two youngest specimens. Both the index and the absolute proportions show a large range of individual variation.

Measurements of orbits.

Male orangs.						Female orangs.					
Catalogue number.	Height.[a]		Breadth.[b]		Mean index.	Catalogue number.	Height.		Breadth.		Mean index.
	Right.	Left.	Right.	Left.			Right.	Left.	Right.	Left.	
	Cm.	*Cm.*	*Cm.*	*Cm.*			*Cm.*	*Cm.*	*Cm.*	*Cm.*	
142183	3.80	3.80	3.35	3.30	116.2	142171	3.45	3.50	3.05	3.05	129.5
142195	3.85	3.90	3.30	3.20	119.2	142201	3.50	3.50	3.45	3.10	100.7
142188	4.00	4.00	3.55	3.45	114.3	142202	3.50	3.55	3.15	3.15	111.9
142200	4.15	4.15	3.50	3.50	118.6	142193	3.55	3.55	3.15	3.00	115.4
142197	4.10	4.20	3.50	3.35	121.3	142170	3.90	3.90	3.10	3.40	114.7
142180	4.20	4.15	3.70	3.50	113.1	142169	3.75	3.80	3.10	3.40	114.0
142181	3.90	3.80	3.35	3.35	114.9	142185	3.80	3.80	3.05	3.10	123.6
142196	3.50	3.75	3.55	3.40	101.3	142187	4.00	3.95	3.45	3.40	116.1
142198	4.55	4.60	3.65	3.65	125.2	142182	3.60	3.70	3.25	3.25	112.3
142191	4.10	4.05	3.50	3.45	117.3	142190	3.70	3.75	3.05	3.10	121.1
142192	4.15	4.15	3.55	3.55	116.9	142186	3.90	3.90	3.25	3.05	123.8
142199	3.95	3.90	3.55	3.60	109.8	142191	3.70	3.80	3.20	3.10	119.0
142189	4.10	4.10	3.35	3.35	122.4						
Average.	4.03	4.04	3.49	3.43	116.5	Average.	3.74	3.77	3.23	3.19	116.8
Range	3.50	3.75	3.30	3.20	104.3	Range	3.50	3.50	3.05	3.00	111.9
	4.55	4.60	3.70	3.65	125.2		4.00	3.95	3.45	3.40	123.8

[a] From about the middle of the lower boundary of the orbit to the highest point above. There is often at the lower edge a slight eversion, or bevelling, which must be neglected, the true boundary of the orbit being just posterior to it.

[b] From a point of meeting of the mesial part of the boundary of the orbit and the fronto-maxillary suture, a landmark which corresponds near to dacryon in man, to the most distant point on the external boundary line of the orbit. Both measurements are conveniently taken with the graduated shaft of the sliding compass, whose extremity has been sharpened, and are, with the index, directly comparable with those obtained by Broca's method in man.

The orbital height follows to a certain extent the growth of the length of the face, but it also bears a special relation to age and particularly to sex. It is, relatively to the facial length, somewhat greater in the young and in the females than in the adults and in the males.

The following table shows these conditions quite clearly:

Relation of the mean height of the orbits to the upper length of the face. Length of the face = 100.

Male orangs.				Female orangs.			
Catalogue number.	Orbito-facial index.	No.	Index.	Catalogue number.	Orbito-facial index.	No.	Index.
142183	48.1	142196	32.3	142171	43.4		
142195	37.2	142198	37.1	142201	43.7	142187	40.1
142188	37.7	142194	33.6	142193	38.6	142182	41.5
142200	40.3	142192	38.5	142170	41.5	142190	40.4
142197	35.2	142199	31.6	142169	37.3	142186	41.5
142180	36.6			142185	42.7	142191	41.6
142181	34.1	142189	37.6				
Average			(of lower 12) 35.5				(of lower 9) 41
Range			31.6–40.3				37.3–41.6

ADDITIONAL CHARACTERISTICS.

The *vault* of the orang skulls has, when viewed from above, a pyriform shape, the smaller extremity corresponding to that part which lies immediately posterior to the orbits. The outline of the lateral plane is oval, while that of the norma occipitalis, without the crests, is intermediary between quadrilateral and circular, never pentagonal as in man.

The forehead, while more or less sloping backward, shows always a good median convexity; in the old males, however, this is nearly obscured by the approximated and prominent temporal ridges.

The features of the vault of paramount interest are the temporal ridges, and the various aspects under which they were found gave rise to much confusion in the earlier contributions on orang craniology and orang species. Doctor Abbott's series of crania shows clearly many important points concerning these features. Up to the completion of permanent dentition the temporal lines are seen to be well apart all along the median line and resemble in every way those in man. During late adolescence, however, these ridges show a rapid approach toward the interparietal articulation and develop into lines of pronounced roughness in the females and into irregularly elevated ridges in the males. In most females they evolve no further than just indicated (as, for example, in Nos. 142193, 142169, 142185, 142186, and 142191), but in some they approach near to junction in the median line (No. 142190), and in others they join for a variable distance from the vertex to the obelion and form a single, low (1 to 3 mm.), sagittal crest, which sometimes shows by a median groove the line of previous separation (Nos. 142170, 142187, and 142182). In males of this series the junction of the advancing rough lines or ridges has taken place in all that reached very near or into adult life (Nos. 142181 to 142189), forming eventually a pronounced sagittal crest which extends over a part of the frontal bone, rises at its highest point to from 1 to 2 cm. in height, and offers a greatly enlarged surface for the attachment of the temporal muscles.

The gradual advance mesiad of the two temporal ridges with the development of the muscles of mastication, the formation at last of the single crest, and the complete disappearance of all traces of the earlier ridges over the parietal bones, constitute a series of the most interesting phenomena in the morphology of the orang skull; and they throw at the same time light on the origin and significance of those abnormally high temporal ridges met with in other animals, and occasionally in the human cranium.[a]

The *lambdoid crests*, serving for the attachment of temporal as well as occipital muscles, develop in both sexes of orangs much earlier than the sagittal. They reach jointly from mastoid to mastoid, forming at lambda a pronounced, rough, triangular tuberosity. In males these crests also, like the sagittal ones, reach much greater proportions than in females. They cause a very early closure of the lambdoid suture.

The *vertical occipital ridge* is comparatively moderate, probably never rising above 4 mm. above the surface of the neighboring bone, and usually being lower. It is more developed in the males.

[a] See A Painted Skeleton from Northern Mexico, by the present writer, American Anthropologist, n. s., III, September–December, 1901.

The *supraorbital ridges*, pronounced in both sexes, are seldom very heavy. They show a marked difference from those in man, consisting in their tapering toward the median line and enlarging outward, up to the malo-frontal suture; in man these ridges are generally most pronounced in their mesial extremity and taper outward.

The *sutures of the vault* show well-developed, often very fine and complex (sagittal and lambdoid), serration. The coronal, the most simple, presents below its middle, in nearly every case where the obliteration is not too advanced, a backward incurvation or angle, the sign of a fetal fontanel and a still earlier developmental separation in this location.[a]

The general order of *synostosis* in the sutures of the vault is lambdoid, sagittal (the two may coincide), coronal, temporo-occipital, temporo-parietal.

Sutural and fontanel ossicles occur not infrequently, but seem to be limited to the posterior part of the skull. There were found several small ones in each asterion in No. 142202; one at right asterion in No. 142195; one in each temporo-occipital in No. 142200; one in right temporo-occipital and one in lambdoid in 142171; three in right and two in left temporo-occipital in No. 142169; several small in right temporo-parietal in No. 142186. Several of the male and three of the female skulls showed advanced obliteration, which involved any accessory bones which may have existed.

In the skull with uncertain sex (No. 142184) there are two sutural bones in the sagittal and one ossicle in each lambdoid articulation, and several in and about each asterion. Other larger sutural bones existed in this specimen along the sagittal, but their boundaries are partly obliterated; a persisting incomplete boundary of one near bregma looks at first sight like a partial parietal suture. Apparently there were in this skull disorders in ossification.

No form of *parietal division* exists in any of the twenty-four skulls.

As to *pterion* the conditions are as follows:

	Male.	Female.
Parieto-sphenoidal articulation, both sides	6	5
Parieto-sphenoidal articulation, right side	0	2
Fronto-temporal articulation, both sides	3	0
Fronto-temporal articulation, left side	0	2
Unrecognizable because obliteration	4	1

The skull of uncertain sex (No. 142184) shows also a bilateral parieto-sphenoidal articulation. The H pterion therefore, or the form which is general in man, occurs also in a very large majority (80 per cent of all the nonobliterated articulations)[b] of these orangs.

[a] For details concerning this feature and bibliography, see A. Hrdlicka, Divisions of the Parietal Bone in Man and Other Mammals, Bull. Amer. Mus. Nat. Hist., XIX, 1903, pp. 231–383.

[b] Anoutchin (Bull. Soc. d'Anthrop., 1878, p. 332) in 65 orang crania found the fronto-temporal articulation on one or both sides in 29.2 per cent of the skulls. Doctor Abbott's collection, reported in similar way, shows the condition in 27.3 per cent of the skulls—results remarkably alike.

The *mastoid* is differentiated, though less so than in man; it is also larger in the males.

Facial features.—The nasal bone is in all the specimens single, but in several of the youngest skulls there can be traced a former median vertical fissure. In several cases the free border shows two lateral fissures, but these have nothing to do with an original, central separation of two nasal components. The bone varies more than any other part of the face in shape and breadth, though in general it tapers from below upward, with a constriction (in most specimens) near the middle. In one of the series it is quite rudimentary (fig. 1). Selenka found various grades of deficiency to a complete absence of these bones in several of his specimens.[a]

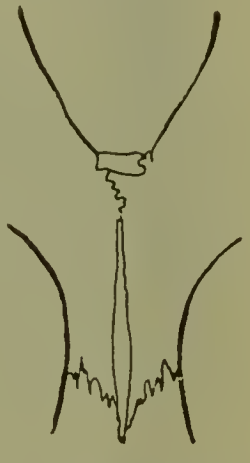

FIG. 1.—RUDIMENTARY NASAL BONE IN THE FEMALE ADULT ORANG. (Cat. No. 142191 U.S. N.M.) (Exact size).

The nose as a whole is leptorhynic, due to the height of the face. The aperture in the nearly grown-up and adult animals differs in shape from vertically elliptical to nearly triangular; it varies in breadth in the adults from 2.5 to 3.2 cm. in the males and from 1.9 to 2.5 cm. in the females. The so-called simian gutters do not occur in the youngest female, but in the other specimens are generally present, though shallow. The inferior boundary of the nose is mostly widely convex, but in several specimens (as, for instance, in No. 142199) it is limited by an easily appreciable ridge.

Nearly all of the specimens show a more or less pronounced elevation corresponding to, and very evidently morphologically identical with, the nasal spine in human skulls.[b] This elevation is particularly prominent (over 3 mm. high) in the female orang (No. 142169), being fully as large and well formed as in occasional human crania (fig. 2).

The malar bones were examined particularly for divisions, but not a trace was found of either sutures or fissures. There was also a complete absence of the maxillary and zygomatic processes which, as W. Gruber first pointed out, in man frequently extend over the ventral surface of the malar, occasionally forming a complete bony arc. In No. 142169, however, are present on the right side two good-sized accessory ossicles, one in the zygomatic and the other at the inferior extremity of the malo-maxillary articulation (fig. 3).[c]

The symphysis of the lower jaw[d] is invariably receding from above

[a] Menschenaffen, pp. 48, 49.

[b] Concerning this point see particularly E. T. Hamy, De l'épine nasale dans l'ordre des primates, Bull. Soc. d'Anthropol. de Paris, IV, 1869, pp. 13–28.

[c] Compare W. Gruber, in the Arch. f. Anat., Physiol., etc., 1873, p. 337.

[d] For detail discussion on the mandible of apes see O. Walkhoff, Der Unterkiefer des Anthropomorphen und des Menschen in seiner funktionellen Entwickelung und Gestalt, in Pt. 4 of Selenka's Studien u. Entwickelungsgeschichte d. Tiere, Wiesbaden, 1902.

downward, but the grade of the obliquity differs. The cause of this slope is, to a large extent, the great development of the alveolar process, itself due in turn to the size of the teeth. Properly speaking, we have here a high degree of mandibular prognathism. The horizontal rami pass backward with a moderate divergence, but the

FIG. 2.—SKULL OF FEMALE ORANG SHOWING NASAL SPINE (Cat. No. 142169 U.S.N.M.).

two rows of teeth, to connect with those of the upper jaw, run nearly or entirely in parallel lines. This gives to each of the horizontal branches a rather pronounced twist, well seen from above, and adds much to the thickness of the upper border behind the second molars.

The vertical ramus in the females approaches in form the same part of the human jaw; in males the posterior border shows a marked rough curve or process, produced by the attachment of the powerful internal pterygoid muscle and the stylo-mandibular ligament.

Base of the skull. The palate approaches ovoid in form—narrower behind than in front, or it is elliptical, or U-shaped. The intermaxillaries are still wholly separated in No. 142171, and the palatal part of their articulation is more or less visible in all the adolescents. The nares are spacious, of somewhat greater height than breadth. The external pterygoid plates are everted; the pterygoid fossa is sometimes deep (as, for instance, in No. 142192); sometimes very shallow (as in the case of No. 142195). The glenoids are broad and shallow, and are bounded externally by the large zygomatic tuberosity, posteriorly by a well developed post-glenoid process, and mesially by a pronounced tuberosity, formed by that part of the temporal which lies next to the petrous bone. This elevation, but feebly represented in human crania, seems to take in part the place of the spinous process, which in the orangs is nearly or wholly absent. The eminentia articularis is very low. The floor of the auditory meati shows no dehiscence.

FIG. 3.—THE RIGHT MOLAR OF FEMALE ORANG (CAT. NO. 142169 U.S.N.M.), SHOWING ACCESSORY OSSICLES AT *x* AND *y*.

The surface of the basilar process is, viewing the base of the skull from above, generally on a lower level than the more elevated parts of the petrous portions of the temporal; and these portions extend forward well upon the body of the sphenoid, leaving only a small side-slit for the middle lacerated foramen. These two features, to which the writer briefly drew attention before,[a] constitute a very good index of the relative development of the brain and skull. In an intellectual white man the petrous portions, looked at from above, are decidedly sunken below the level of the neighboring parts, which offered less

[a] Certain Racial Characteristics of the Base of the Skull. (Abstract.) Rept. Section Anthropology and Psychology, N. Y. Acad. Sci., Science, Feb. 22, 1901, p. 309.

resistance than these hard wedges to the expansion of the brain: and the middle lacerated foramina are large, through the spreading of the surrounding parts, while the petrous bones remained stationary. In the African blacks the petrous portion and surface of neighboring bones are often on the level and the middle lacerated space is small, while in the Indians, brown, and some yellow races the conditions are mostly between those of the white and black. The whole process of the changing relations and gradual enlargement of the middle perforated space can be studied in whites alone from childhood to adult life. In all the apes and monkeys and in other mammals the middle perforated space is insignificant and the relative elevation of the petrous portions equals or exceeds that in the orangs.

There are present in a number of the skulls distinct styloids. The detail conditions in this respect are as follows:

Styloids.

Male orangs.						Female orangs.					
Cat. No.	Right length.	Left length.	Cat. No.	Right length.	Left length.	Cat. No.	Right length.	Left length.	Cat. No.	Right length.	Left length.
	mm.	*mm.*		*mm.*	*mm.*		*mm.*	*mm.*		*mm.*	*mm.*
142183	None.	None.	142196	Trace.	Trace.	142171	None.	2	142185	None.	Trace.
142195	None.	None.	142198	Trace.	Trace.	142201	None.	2	142187	11	7
142188	6	1	142194	Trace.	Trace.	142202	4	2	142182	1	1
142200	None.	Trace.	142192	3	2	142193	None.	None.	142190	2	?
142197	2	3	142199	5	6	142170	1	1	142186	2	2
142180	Trace.	Trace.	142189	4	2	142169	5	6	142191	4	3
142181	3	4									

In nearly all of the specimens is seen a special spinous process, descending from the petrous bone, anterior to the carotid aperture, to the basilar process in front of the jugular foramen. In a few cases a similar process rises from the basilar, and where the two join (as, for instance, in No. 142183) there is formed a petro-basilar bridge and canal. In three instances (Nos. 142202, 142199, and 142189) there is an incomplete bridge in the usual place, and a second complete one or nearly so, a little more anteriorly. The part of the bridge projecting from the petrous bone is already well developed in the youngest skulls of both sexes.

The anterior condyloid foramen (which in man is usually single and transmits the twelfth cranial nerve with a meningeal branch of the ascending pharyngeal artery and its accompanying veins) was found in these, as in previously reported (Owen) orangs, to be almost generally double: or there is a single large mouth of two canals, both of fair size (though one, the more anterior, is mostly larger). In only three out of the twenty-six skulls were both the foramen and canal single, and in only one of these (No. 142199) they were so bilaterally. On the other hand, in four skulls (Nos. 142188, 142181, 142196, and 142201) there were on one side, always the left, three separate canals and foramina.

The posterior condyloid foramina, such as occur somewhat irregularly in man and each of which transmits a vein from the lateral sinus, are absent in the orangs. There are, near the usual location of these foramina in a number of the skulls very small single orifices, usually less than 1 millimeter in diameter, but these are only the openings of the canals of nutrient vessels. The posterior condyloid fossa, however, and the groove leading from it to the anterior condyloid depression, are invariably well represented, particularly so in the male skulls.

The articular surface of the condyles, often double in man, is single in all these specimens.

The foramen magnum differs greatly in size and shape, as will best be seen from the following figures:

Measurements of foramen magnum.

Male orangs.			Female orangs.		
Cat. No.	Greatest length.	Greatest breadth.	Cat. No.	Greatest length.	Greatest breadth.
	cm.	*cm.*		*cm.*	*cm.*
142183	3.3	2.2	142201	3.9	2.7
142188	2.9	2.4	142170	3.0	2.5
142181	3.3	2.8	142169	2.9	2.6
142198	3.5	2.7	142182	2.3	2.4
142194	4.1	3.2	142186	3.7	3.05
142189	3.8	2.7			

It would be interesting to know the height of the different animals, to see what relation it bears to the size of the cord and foramen. The length of the aperture is often augmented by a broad notch in the posterior border, and this affects also the plane of the foramen. No such notch occurs normally in man. The axes of the orbits would pass, if prolonged, through the foramen magnum in all the specimens.

The point of insertion of the middle odontoid ligament on the center of that part of the basilar process which forms the anterior boundary of the foramen magnum is in most of the skulls very rough, and in some (Nos. 142181, 142189, 142169, 142185, and 142182) a process projects here into the lumen of the foramen. This process occurs also, though much less frequently, in man, and has sometimes erroneously been described as the third condyle.

None of the specimens under examination shows the oval mediobasilar ("pharyngeal") fossa, or any tubercles, such as can occasionally be found in man, on the anterior border of the foramen magnum; nor is there any trace of a true third condyle.

The base of the skull being damaged in a number of the specimens, and the calvarium being cut in others, it was possible to make a few observations also on some of the *central parts* of the crania.

The frontal bone shows in some of the specimens quite marked impressions of the brain convolutions, but in others it is nearly

smooth. The lower portion of the metopic crest is, in a large proportion of the skulls, absent or nearly so, the ethmoid depression is very deep, the crista galli insignificant, though not wholly wanting. The outline of a horizontal plane of the skull above the orbits is nicely ovoid, differing from that in man by greater convergence of the parieties toward the median line in front; in other words, the frontal region

FIG. 4.—SKULL OF MALE ORANG (Cat. No. 142198 U.S.N.M.). *a*, ARCH IN THE DORSUM SELLÆ: *f* COMPLETE FENESTRUM ABOUT THE GASSERIAN GANGLION.

of the orang brain is more pointed than in man. In the gibbon and lower primates this condition is still more accentuated.

The spinous foramen is absent; it is merged with the foramen ovale, which is spacious.

The middle and posterior clinoids, and in some cases the anterior ones also, are united by a bridge which completes a large pituitary foramen. In six cases only is this union wanting and in two others it is on one side incomplete. The dorsum sellæ is in seventeen skulls (11

males, 6 females) an arch over a large foramen (see fig. 4*a*), in six (1 male, 5 females) it consists only of two diverging laminæ with wide mesial separation, and in one case (female, No. 142201) there are only traces of even these laminæ.

The lateral borders of the dorsum sellæ or its components, articulate at their base, in many of the specimens, with a process from the point of the petrous part over a quite spacious canal for the inferior petrosal sinus; and a little farther laterad the free superior border of the petrous bone shows a marked oval depression for the Gasserian ganglion. This hollow is more pronounced than in man; in some of the speci-

FIG. 5.—SKULL OF FEMALE ORANG (Cat. No. 142170 U.S.N.M.), SHOWING A DIMINUTION IN SIZE OF THE MOLARS FROM THE FIRST BACKWARDS.

mens projecting spiculæ from the superior border of the petrous bone convert it into an incomplete foramen; and in one case (No. 142198) there is on the right side a union of these processes, from which results a complete spacious bony fenestrum (fig. 4*f*). This feature, so far as the writer could find, has not been reported previously either in apes or man.

The teeth.—Orang teeth in general have been studied thoroughly by Selenka,[a] and there will be added in this place only a few particulars.

The male teeth are all larger than the corresponding ones of the

[a] Menschenaffen, p. 57 et seq.

females and the latter also approach more the human form. In some of the females (as, for instance, No. 142170) the upper molars diminish very perceptibly from the first to the third and are also not far from

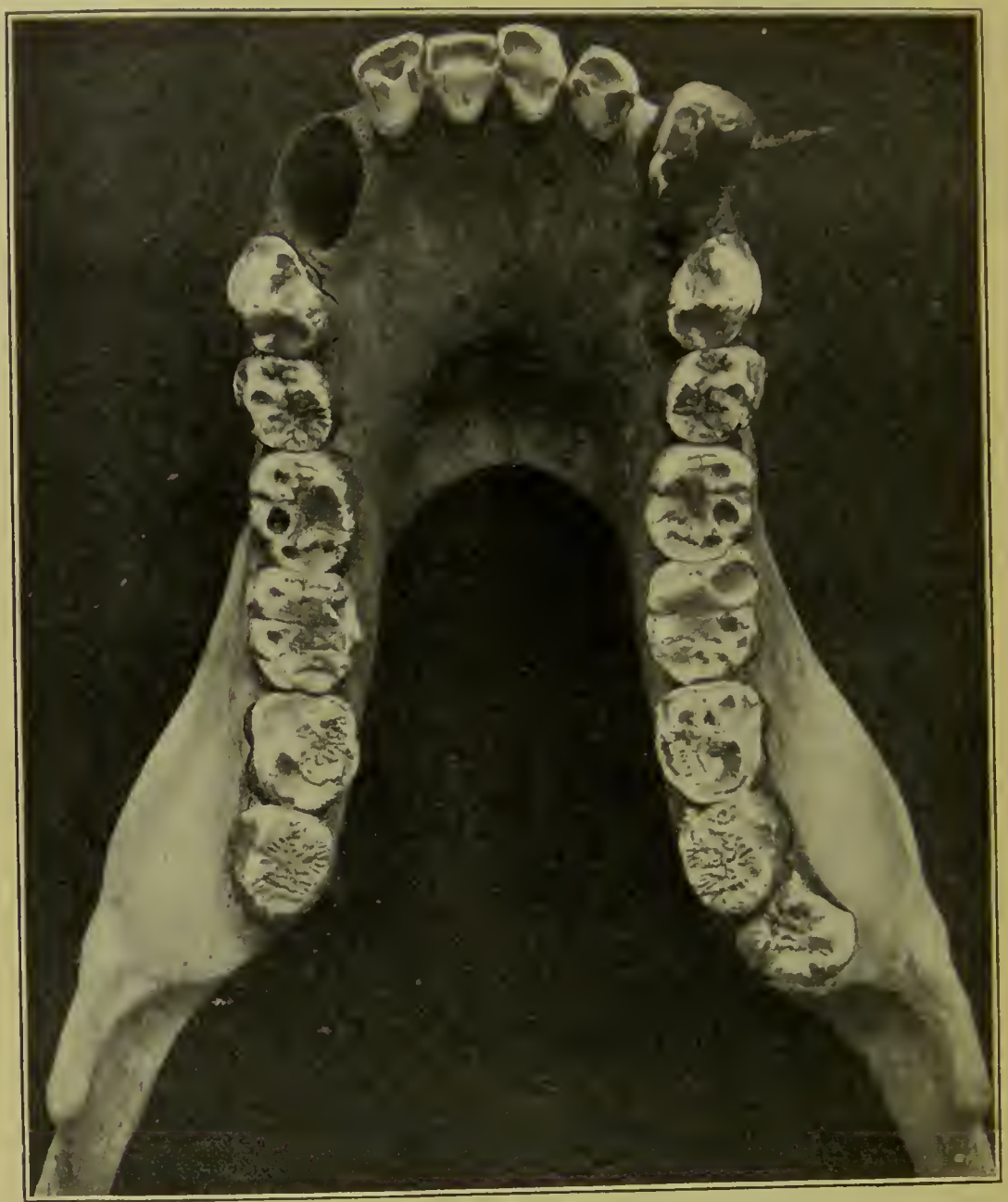

FIG. 6.—MANDIBLE OF MALE ORANG (Cat. No. 142199 U.S.N.M.), SHOWING FOUR TRUE MOLARS ON THE LEFT AND FIVE ON THE RIGHT SIDE.

human teeth in size (maximum length of the three superior molars 3.25 cm., mean in two average men 3.2 cm.; maximum breadth 1.35 cm., mean in two men 1.25 cm.) (fig. 5).[a]

In a number of the specimens are found supernumerary teeth, while

[a] See also fig. 13, in Gaudry, Sur la similitude des dents de l'homme et de quelques animaux, L'Anthropologie 1901, p. 93.

in one the right third lower molar seems to be permanently wanting. Among the 12 males and 10 females with full second dentition the conditions are as follows:

Dentition.

	Male.				Female.			
	Above.		Below.		Above.		Below.	
	Right.	Left.	Right.	Left.	Right.	Left.	Right.	Left.
Normal dentition (2–1–2–3)	10	11	9	9	10	10	8	10
Two molars only			[a]1					
Four molars	2		1	3			[b]2	
Five molars			[c]1					
A supernumerary canine		[d]1						

[a] No. 142181.
[b] No. 142199 (upper right); No. 142195 (upper left); No. 142180 (lower both sides); No. 142198 (lower left); No. 142199 (lower left); No. 142170 (lower right); No. 142190 (lower right).
[c] No. 142199.
[d] No. 142181.

The fifth molar in No. 142199, a fully adult male, is of large size, but only about half erupted (fig. 6), so that it shows at the same time an example of late dentition. The supernumerary tooth in No. 142181 (fig. 7) is situated ventrally and in apposition to the regular canine, touching also the lateral incisor. It is not as large as the canine proper, but is decidedly broader and higher than any of the incisors. The left side of the lower jaw, which contains this tooth, is longer than the right, which renders the front of the bone asymmetric (the right side of this jaw presents a crowding of the premolars and an absence of the third molar, though there is not a lack of space for this last). Selenka found[a] in his collection dental anomalies of the following varieties and proportions:

Dental anomalies.

	84 grown males.	110 grown females.
Fourth molar below on right side in	2	1
Fourth molar below on left side in	3	2
Fourth molar below on both sides in	4	6
Fourth molar above on right side in	0	2
Fourth molar above on left side in	4	1
Fourth molar above on both sides in	2	1
Fourth molar above on left and below on right side in	0	1
Fourth molar above on left and below on both sides in	0	2
Fourth molar above on right and below on both sides in	2	0
Fourth molar above on both sides and below on left side in	1	0
Fourth molar above and below on both sides in	2	1
Five molars on each side above with 4 on each side below in	1	0
Total of cases	21	17

Besides the above, Selenka observed three supernumerary premolars (two above in one skull, one below), and one supernumerary incisor (details not given). Extra molars, it is seen from both series, predominate in males and in the lower jaw, where the teeth in general show a greater development. In No. 142198 of Doctor Abbott's series the fourth lower molar is rudimentary (fig. 8).

[a] Menschenaffen, pp. 90–91.

The study of orang crania as a whole impresses one with the high degree of individual variation and with the rôle played by the muscles and teeth in modifying various parts. As both of these agencies are mainly connected with the kind of food, the plausible suggestion forces itself upon the mind that a prolonged change, lasting through a number of generations, to food requiring much less mastication should

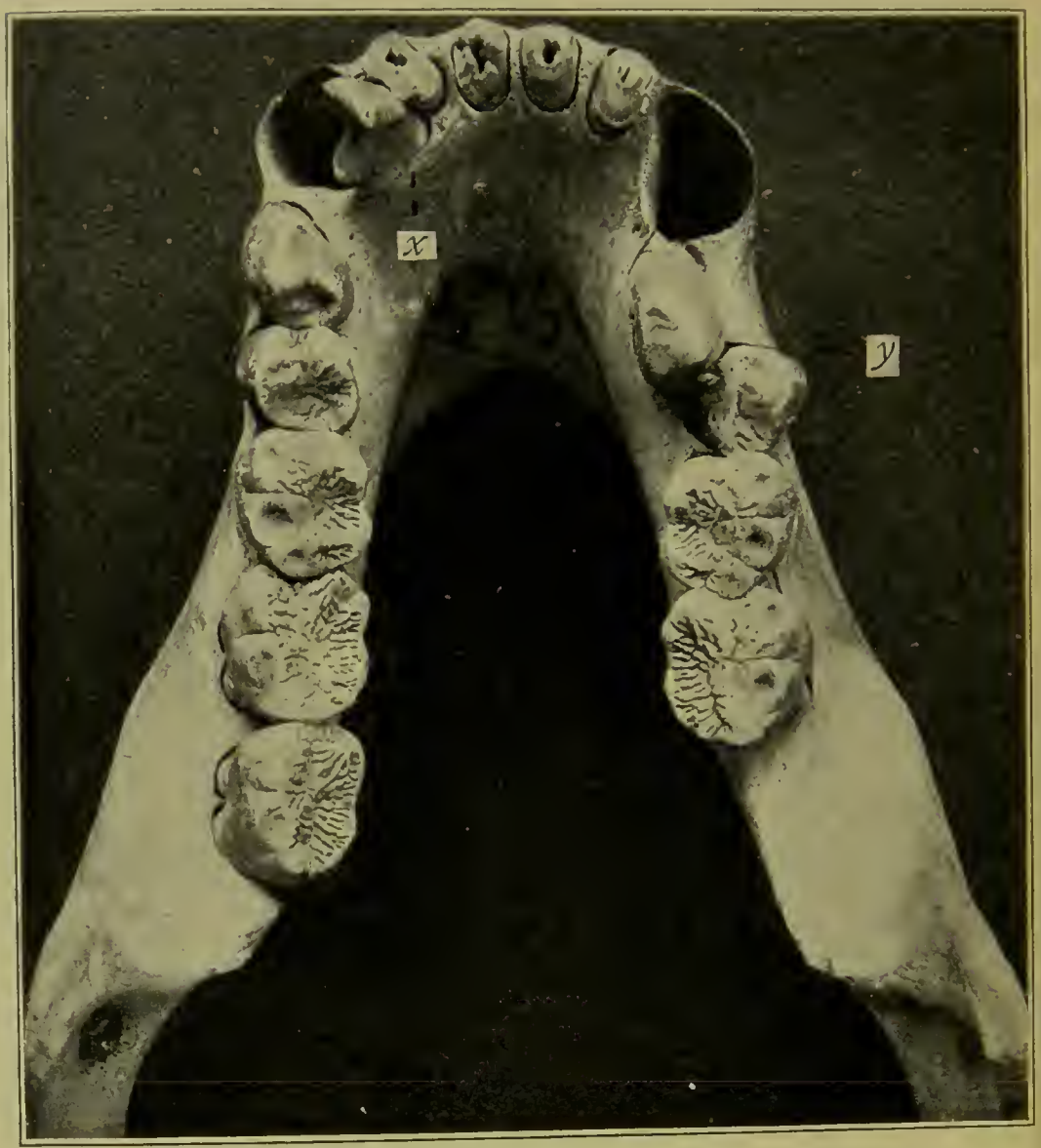

FIG. 7.—MANDIBLE OF ADULT MALE ORANG (Cat. No. 142181 U. S. N. M.). *x*, A SUPERNUMERARY TOOTH: *y*, IRREGULARITY OF THE PREMOLARS. THE RIGHT RAMUS EXHIBITS ONLY TWO MOLARS.

greatly modify the whole orang skull. It should also bring it nearer to the human type, for the features by which the orang cranium differs most from the human are with few exceptions exactly those produced by greater teeth and muscles of mastication.

As this paper goes to print word is received from Doctor Abbott of a shipment to the National Museum of further material, consisting of eighteen crania and skeletons of orangs from Sumatra; these

ought to prove of great interest in connection with the Borneo material here described.

An endeavor has been made by the writer to collect the bibliography of writings relative to or dealing with orang craniology. This proved

FIG. 8.—MANDIBLE OF FEMALE ORANG (Cat. No. 142198 U.S.N.M.), SHOWING A RUDIMENTARY FOURTH MOLAR ON THE LEFT.

to be an arduous task, though the number of larger contributions to the subject is limited. The following pages contain all the works that could be personally examined, and there were only a few obscure titles where this was not possible:

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For other notes on Orang crania see general works on zoology and comparative anatomy.